Solutions

Each answer shows the steps, then the **result**.

2.1

- the force multiplied by the **perpendicular distance**
- from the point to the **line of action** of the force

2.2

- moment of a force, $M = Fd$

$$M = Fd = 20 \text{ N} \times 0.30 \text{ m} = \mathbf{6.0} \text{ N m}$$

2.3

- moment of a force, $M = Fd$, on each side

$$M_{\text{acw}} = Fd = 250 \text{ N} \times 1.2 \text{ m} = 300 \text{ N m}$$

$$M_{\text{cw}} = Fd = 300 \text{ N} \times 0.80 \text{ m} = 240 \text{ N m}$$

- resultant moment $= M_{\text{acw}} - M_{\text{cw}} = 300 - 240 = \mathbf{60}$ N m
- **anticlockwise**: the left-hand side goes down

2.4

- two forces **equal** in size and **opposite** in direction 、
- with **parallel** lines of action that are **separated** (not the same line)

2.5

- torque of a couple, $\tau = Fd$, with d the separation of the two lines of action, $d = 0.050 + 0.050 = 0.10$ m

$$\tau = Fd = 12 \text{ N} \times 0.10 \text{ m} = \mathbf{1.2} \text{ N m}$$

3.1 B

- torque = one force × the separation of the lines of action, which is the diameter: $\tau = Fd = 15 \times 0.36 = 5.4$ N m
- **A** uses the radius; **C** uses both forces and the diameter; **D** divides the force by the radius A C D

3.2 A

- the two forces of a couple are equal and opposite, so the resultant force is zero and the only effect is rotation 、
- **D** doubles the torque; **B** and **C** give a resultant force that a couple does not have D B C

3.3

(a) one of the forces multiplied by the perpendicular distance

- between the lines of action of the two forces

(b) torque of a couple, $\tau = Fd$, with d the separation of the two lines of action, $d = 2.3 + 2.3 = 4.6$ m

$$\tau = Fd = 40 \text{ N} \times 4.6 \text{ m} = \mathbf{184} \text{ N m}$$

(c) the resultant force is **zero**

- the satellite rotates (with increasing angular speed), but its centre of gravity does not accelerate

(d) there is now a resultant force of 40 N

- so the satellite accelerates in the direction of that force, and it still turns because the force has a moment about the centre of gravity

3.4

(a) at its **centre**, 1.5 m from each end 1.5 m

- the plank is **uniform**, so its centre of gravity is at its middle

(b) moment of a force, $M = Fd$, with $d = 1.2$ m 1.2 m

$$M = Fd = 300 \text{ N} \times 1.2 \text{ m} = \mathbf{360} \text{ N m anticlockwise}$$

(c) the weight acts at the centre, $d = 1.5 - 1.2 = 0.30$ m to the right of the pivot, and $M = F_W d$

$$M = F_W d = 220 \text{ N} \times 0.30 \text{ m} = \mathbf{66} \text{ N m clockwise}$$

(d) it turns **anticlockwise**: the left-hand end goes down

- the anticlockwise moment, 360 N m, is greater than the clockwise moment, 66 N m

(e) the child must supply the missing clockwise moment, $M = M_{\text{acw}} - M_{\text{cw}} = 360 - 66 = 294$ N m

- the child sits at the end, $d = 3.0 - 1.2 = 1.8$ m from the pivot, and $M = F_W d$

$$F_W = \frac{M}{d} = \frac{294 \text{ N m}}{1.8 \text{ m}} = \mathbf{160} \text{ N}$$